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ABSTRACT

Guidelines for changing to the metric system of measurement with regard to all phases of home economics are presented in this handbook. Topics covered include the following: (1) history of the metric system, (2) the International System of Units (SI): derived units of length, mass, time, and electric current; temperature; luminous intensity; prefixes; amount of substance; tables of SI, and common metric units and symbols, (3) soft and hard conversion, (4) metric usage in home economics in the areas of food, nutrition, clothing, housing and home furnishings, and household equipment, (5) general style and usage for abbreviations, symbols, capitals, compound units, decimals, derived units, nomenclature, plurals, spacing, conversion, rounding, metric arithmetic, and pronunciation, and (6) learning activities: food, nutrition, clothing, home furnishings, and household equipment. Appendixes contain information on conversion factors, provide conversion tables (for volume, temperature, gauge pressure at sea level and boiling point of water, and oven temperature in degrees Celsius), references, a selected bibliography for metrication in home economics, and guidelines for selecting metric instructional materials. (TA)

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Handbook for
Metric Usage

FIRST EDITION

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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MULTIPLES AND PREFIXES
These Prefixes May Be Applied To All SI Units

Multiples and Submultiples		Prefixes	Symbols
1 000 000 000 000 =	10^{12}	tera (ter′a)	T
1 000 000 000 =	10^{9}	giga (jī′ga)	G
1 000 000 =	10^{6}	mega (meg′a)	M
1 000 =	10^{3}	kilo (kil′ō)	k
100 =	10^{2}	hecto (hek′tō)	h
10 =	10^{1}	deka (dek′a)	da
Base Unit 1 =	10^{0}		
0.1 =	10^{-1}	deci (des′i)	d
0.01 =	10^{-2}	centi (sen′ti)	c
0.001 =	10^{-3}	milli (mil′i)	m
0.000 001 =	10^{-6}	micro (mī′krō)	μ
0.000 000 001 =	10^{-9}	nano (nan′ō)	n
0.000 000 000 001 =	10^{-12}	pico (pē′kō)	p
0.000 000 000 000 001 =	10^{-15}	femto (fem′tō)	f
0.000 000 000 000 000 001 =	10^{-18}	atto (at′tō)	a

From U. S. Department of Commerce, National Bureau of Standards

PREFACE

Almost every activity in home economics requires measurements of one sort or another. Measurements are involved in purchasing clothing, food, fabric, home furnishings, household equipment, kitchen cabinets, lumber, and other supplies. Measurements of weight, volume, length, and temperature are required in much household work such as food preparation, clothing construction, laundering and use of laundering aids, cleaning and use of cleaning products, and gardening and use of insecticides.

With the adoption of the metric system in the United States, people will need to learn new units of measurement. Fortunately, some units that we now use will not be changed, some in the metric system will never be used by the average consumer, and only a few units will be used frequently.

Many workshops, books, and journal articles have been prepared to help the prospective user learn the metric system. Some of the materials are not accurate, and some place emphasis on conversion rather than on direct use of metric measurement.

The Metric Committee of the American Home Economics Association was asked to take the leadership in the change to the metric system of measurement with regard to all phases of home economics. Home economists concerned with learning, teaching, and developing materials for use with the metric system need accurate, uniform information consistent with international standards of usage. The committee has prepared these guidelines of background information for their use. Units included are those likely to be most frequently needed in various areas of home economics.

Although conversion information is included, the committee recommends that people learn to think in The International System of Units (SI) and that conversion factors not be memorized. Learning will be facilitated and chances of error will be lessened if we become familiar with actual sizes and quantities of the new units and use the tools for measurement calibrated in those units. As when one learns another language, adoption of the metric system has been smoother in countries where people did not rely on translations and dual measurements.

The committee recommends that users learn the language first, think and measure metric, and convert only when necessary.

The information included in this handbook is consistent, whenever possible, with that distributed by the National Bureau of Standards, the American National Metric Council, and the American National Standards Institute. The latter organization is the official representative of the United States to the International Organization for Standardization (ISO).

Olive M. Batcher, Chairman
Metric Committee
1977

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1

HISTORY

The U.S. customary system of measurements is a hodgepodge of Anglo-Saxon, Roman, and Norman-French weights and measures. Many monarchs appointed commissions to create order out of the chaos of measurement by establishing standards for the more common measurements. Thus, the inch was defined as "the length of 3 barleycorns, round and dry."

To establish order in the marketplace, the framers of the Constitution gave Congress the power to fix the standards of weights and measures.

Thomas Jefferson devised two systems (one based on the swing of a pendulum and the other on decimal ratios) in response to President George Washington's reminder to Congress in 1790 that it was time for the United States to set its own standards of weights and measures. Neither system was adopted by Congress, however.

Also in 1790, the French National Assembly requested the French Academy of Sciences to develop an "invariable standard for all measures and all weights." The Academy proposed the unit of length (meter) as a portion of the earth's circumference and units of capacity and mass as derivations of the unit of length. The cubic decimeter (a cube 1/10 of a meter on each side) was chosen as the unit of fluid capacity and was called a liter. The metric unit of mass (gram) was defined as the mass of one cubic centimeter (a cube that is 1/100 of a meter on each side) of water at its temperature of maximum density. Measures larger and smaller than the base unit were related by decimal ratios. Originally, time and angles were also divided decimally and for a while during the Revolution, Frenchmen lived on a 10-day week.

The metric system was not generally accepted until its use was made compulsory in France in 1840. Then, the system began to spread rapidly to other nations.

In 1866, Congress made it "lawful throughout the United States of America to employ the weights and measures of the metric system in all contracts, dealings, or court proceedings."

In 1875, the Treaty of the Meter set up well-defined metric standards for length and mass and established a permanent International Bureau of Weights and Measures. A General Conference on Weights and Measures meets periodically to handle all international matters concerning the metric system. The United States was one of 17 nations that signed the treaty.

In 1881, the International Congress of Electricity adopted the centimeter-gram-second system (cgs) in which time was added to length and mass measurements.

Since 1893, the fundamental weights and measures standards in the United States have been based on the internationally agreed-to standards; that is, pound, foot, etc. are defined in metric units.

In 1950, the meter-kilogram-second system (MKS) was linked to the electromagnetic system of units with the adoption of the ampere, the unit of electrical current.

In 1954, at the 10th General Conference of Weights and Measures, the units for temperature (kelvin) and luminous intensity (candela) were adopted.

At the 11th General Conference in 1960, the system was formalized to Le Système International d'Unités (SI). Thirty-six countries, including the United States, were represented. The conference established the base, supplementary, and derived units; symbols; and prefixes to be used, eliminating much of the confusion which had been created over the years. Some units were redefined to correct errors in original measurements and calculations.

The mole was adopted as the unit for the amount of substance, at the 14th General Conference in 1971, thus completing the set of seven base units in the modern metric system. Further improvements and additions to SI will be made at future general conferences, but they will not likely affect daily use of the system by the average person.

The Metric Conversion Act of 1975 was signed into law on December 23, 1975. The act states that "the policy of the United States shall be to coordinate and plan the increasing use of the metric system in the United States and to establish a United States Metric Board to coordinate the voluntary conversion to the Metric System."

2

THE INTERNATIONAL SYSTEM OF UNITS (SI)

The first step in adopting the metric system is to understand the language. Le Système International d'Unités (SI) or the modern metric system was developed at the 11th General Conference of Weights and Measures in 1960. The system is composed of well defined units of measurement including base, supplementary, and derived units plus prefixes.

Base units are those which by convention are considered dimensionally independent. Supplementary units are the units which were not designated as either base or derived units by the General Conference. All other SI units of measurement are derived from combinations of base and supplementary units; some with special names are shown in Table 1.

Each metric unit is represented by a symbol. The symbol is the same in all languages although the unit names may be spelled differently.

Length

The *meter* (m), the SI base unit of length, was redefined at the 11th General Conference in terms of wavelength (1 650 763.73 wavelength of the radiation in vacuum of the orange-red line of the spectrum for the atom of krypton-86). The meter replaces inch, foot, yard, and mile.

The spelling of "meter" in the United States has evoked much discussion. In 1975, the American National Metric Council and the National Bureau of Standards adopted "meter" as the preferred spelling in their publications. The American Home Economics Association has adopted this spelling to be consistent with these publications. Some foreign countries and some associations in the United States use "metre," the spelling in the international standard.

Derived Units: Length

Area. The SI unit for area is square meter (m^2). The square meter replaces square foot, square yard, and acre in the customary system.

Volume. The SI unit for volume is cubic meter (m^3). The cubic meter replaces cubic foot, cubic yard, and other units of volume. It is the measure of three-dimensional space—whether occupied or empty, fluid or dry, regular or irregular. The symbol "cm"' is to be

Table 1.—The International System of Units (SI)

Base and supplementary SI units			Some derived SI units			
Quantity	Name	Symbol	Quantity	Name	Symbol	Expression in terms of SI base or other units
Base Units						
Length	meter	m	area	square meters	m^2	
			volume	cubic meter	m^3	
			density	kilogram per cubic meter	kg/m^3	
Mass	kilogram	kg	force	newton	N	$kg \cdot m/s^2$
			pressure, stress	pascal	Pa	N/m^2
			energy, work, quantity of heat	joule	J	$N \cdot m$
			power	watt	W	J/s
Time	second	s	speed, velocity	meters per second	m/s	
			acceleration	meters per second squared	m/s^2	
			frequency	hertz	Hz	1/s
Electric current	ampere	A	electric force or potential	volt	V	W/A
			electric resistance	ohm	Ω	V/A
Thermodynamic temperature	kelvin	K	temperature	degrees Celsius	°C	
Luminous intensity	candela	cd	luminous flux	lumen	lm	$cd \cdot sr$
			illuminance	lux	lx	$cd \cdot sr/m^2$
Amount of substance	mole	mol	concentration	mole per cubic meter	mol/m^3	
Supplementary Units						
Plane angle	radian	rad				
Solid angle	steradian	sr				

used for cubic centimeter, not the abbreviation "cc."

Fluid Volume. The liter (0.001 cubic meter) is commonly used to measure fluid volume. Although not an SI unit, its use is expected to be continued more or less indefinitely. In 1975, the American National Metric Council and the National Bureau of Standards adopted "liter" as the preferred spelling. The American Home Economics Association has adopted this spelling to be consistent. Some U.S. metric associations have adopted "litre" which is also used in many foreign countries including Canada.

The lowercase "ell" as the symbol for liter has not been satisfactory because it is indistinguishable from the numeral "1" on most typewriters. Several countries have adopted the script "l" which requires replacing a scarce typewriter key. The capital "L" is receiving international acceptance. It is preferable to spell the word in full wherever possible, however.

Mass

Mass is the quantity of matter contained in an object and is independent of location of the object in the universe; its unit of measure is the *kilogram* (kg). Weight is the term commonly used to mean mass.

The *kilogram* (kg), the SI base unit for mass, was defined as the mass of a particular cylinder of platinum-iridium alloy called the International Prototype Kilogram. The mass is preserved in a vault at Sevres, France, by the International Bureau of Weights and Measures. A duplicate, in the custody of the National Bureau of Standards, serves as the mass standard for the United States. The kilogram is the only SI base unit still defined by an artifact and containing a prefix. Kilogram replaces ounces and pounds.

Derived Units: Mass

Force. The SI unit for force is the *newton* (N), defined as the force which, when applied to one kilogram mass, will give the kilogram mass an acceleration of one meter per second squared ($kg \cdot m/s^2$). The term kilogram-force is not used. Newton replaces pounds-force.

Pressure. Pressure is force per unit area and the SI unit for pressure is the *pascal* (Pa). One pascal is defined as one newton per square meter (N/m^2). Pascal replaces pounds-force per square inch.

Work and Energy. The SI unit for work and energy of any kind is the *joule* (J). The joule is defined as work done in moving one kilogram of mass through one meter of space ($N \cdot m$). Like the calorie, the joule is too small for everyday use; the kilojoule will be commonly used.

Quantity of Heat. The joule will replace calorie and British thermal unit. A calorie is the amount of heat (thermal energy) necessary to raise the temperature of one gram of water at 15 °C by 1 °C. It cannot be derived from base units without using an experimentally determined factor; thus, a calorie is not an SI unit.

Power. The SI unit for power of any kind is the *watt* (W). One watt equals one joule of work done in one second of time (J/s or $N \cdot m/s$).

Time

The SI base unit for time is the *second* (s) and is the same in metric and custom-

ary units. It is defined as the duration of 9 192 631 770 cycles of the radiation associated with a specified transition of the cesium-133 atom. There are still 60 seconds in a minute (min), 60 minutes in an hour (h), and 24 hours in a day (d). Minutes, hours, and days are authorized non-SI units.

Derived Units: Time

Frequency. The SI derived unit for frequency, or number of periods or cycles per second, is the *hertz* (Hz). One hertz is equal to one cycle per second (s^{-1} or 1/s).

Speed. The SI unit of speed or velocity is *meter per second* (m/s).

Acceleration. The SI unit of acceleration is *meter per second squared* (m/s^2). Acceleration is the rate of change of speed with time.

Electric Current

The SI base unit for electric current is the *ampere* (A) and is the same in metric and U.S. customary units. An ampere is defined as that current which, if maintained in each of two long parallel wires separated by one meter in free space, would produce a force between the two wires of 2×10^{-7} newton for each meter of length.

Derived Units: Electric Current

Force or Potential. The unit of electromotive force or electric potential is the *volt* (V). One volt equals 1 watt per ampere (W/A).

Table 2—**Common Metric Units and Symbols**

Quantity	1/1 000 000	1/1000	1/100
Length	micrometer (μm)	millimeter (mm)	centimeter (cm)
Volume		milliliter (mL)	
Mass	microgram (μg)	milligram (mg)	
Energy			
Power			
Electromotive force		millivolt (mV)	
Temperature			
Frequency			
Electric current	microampere (μA)	milliampere (mA)	
Time	microsecond (μs)	millisecond (ms)	

Resistance. The SI unit of electrical resistance is the *ohm* (Ω). One ohm equals 1 volt per ampere (V/A).

Temperature

The SI base unit for thermodynamic temperature is the *kelvin* (K). The kelvin is defined as the fraction 1/273.16 of the thermodynamic temperature of the triple point of water (the temperature at which water can exist in all three states—vapor, liquid, and solid). The temperature 0 K is called "absolute zero."

Celsius Temperature. For normal use, the kelvin is difficult to measure. The intervals on the kelvin and commonly used Celsius (formerly Centigrade) scales are the same and therefore the Celsius scale is used for practical temperature measurements. Celsius temperature of 0 °C is defined as 273.15 K and is the freezing point of water, and 100 °C is 373.15 K, the boiling point of water. Prefixes are not used with temperature measurements. The interval 1 K or 1 °C is about 1.8 °F; 0 °C equals 32 °F; 100 °C equals 212 °F.

Luminous Intensity

The SI base unit for luminous (light) intensity is the *candela* (cd). The candela is defined as the luminous intensity of 1/600 000 of a square meter of a black body at the temperature of freezing platinum (2045 K). Platinum is hot and glows at this state. Light from the flame of a candle 25 mm in diameter is equivalent to about one candela.

Luminous Flux. The SI unit of light

Standard	1000	1 000 000
meter (m)	kilometer (km)	megameter (Mm)
liter (L)		
gram (g)	kilogram (kg)	megagram (Mg)
joule (J)	kilojoule (kJ)	megajoule (MJ)
watt (W)	kilowatt (kW)	megawatt (MW)
volt (V)		
degree Celsius (°C)		
hertz (Hz)	kiloampere (kA)	megahertz (MHz)
ampere (A)		
second (s)	kilohertz (kHz)	kilosecond (ks)

Prefixes

Prefixes designating metric units larger than one are Greek terms; those less than one are Latin derivations.

Prefix	Symbol	Factor		
exa	E	10^{18}	or	1 000 000 000 000 000 000
peta	P	10^{15}	or	1 000 000 000 000 000
tera	T	10^{12}	or	1 000 000 000 000
giga	G	10^{9}	or	1 000 000 000
mega	M	10^{6}	or	1 000 000
kilo	k	10^{3}	or	1 000
hecto	h	10^{2}	or	100
deka	da	10^{1}	or	10
deci	d	10^{-1}	or	1/10
centi	c	10^{-2}	or	1/100
milli	m	10^{-3}	or	1/1000
micro	μ	10^{-6}	or	1/1 000 000
nano	n	10^{-9}	or	1/1 000 000 000
pico	p	10^{-12}	or	1/1 000 000 000 000
femto	f	10^{-15}	or	1/1 000 000 000 000 000
atto	a	10^{-18}	or	1/1 000 000 000 000 000 000

While *hecto, deka,* and *deci* are recognized SI prefixes, they will not be generally used in the United States. **Centi** should be used only with the unit for length (meter). The average citizen will not be likely to encounter amounts smaller than **micro** or larger than **mega.** Therefore, only five prefixes need to be mastered—**mega, kilo, centi, milli,** and **micro.**

flux is the *lumen* (lm) which is defined as the luminous flux emitted in a solid angle of one steradian by a point source having a luminous intensity of one candela. A 100-watt incandescent light bulb emits about 1700 lumens. An incandescent light emits 10-20 lumens for each watt of energy consumed, whereas a fluorescent light emits 60 lumens or more for each watt. One lumen equals 1 candela times 1 steradian (lm = cd·sr).

Amount of Substance

The base unit for amount of substance is the *mole* (mol). A mole contains as many elementary entities as there are atoms in 0.012 kilogram (12 grams) of carbon-12. The elementary entities must be specified and may be atoms, molecules, electrons, ions, other particles or specified groups of such particles. A mole has been defined as the mass numerically equal to the molecular weight.

Concentration. The SI unit of concentration is *mole per cubic meter* (mol/m^3).

Supplementary Units

Plane Angle. The *radian* (rad), an SI supplementary unit, is the plane angle defined as the arc of a circle equal in length to the radius.

Solid Angle. The *steradian* (sr), an SI supplementary unit, is the solid angle defined in terms of a square on the surface of a sphere whose sides are equal in length to the radius.

3

SOFT AND HARD CONVERSION

It is not easy to convert from our U.S. customary system of measurement to the metric system because of the hodgepodge of units and conversion factors in the customary system. There are two approaches to the change to metric units—soft conversion and hard conversion.

Soft Conversion. Change which is merely one of vocabulary or nomenclature is known as soft conversion. Dimensions are described in metric rather than U.S. customary units. Thus, one inch becomes 25.4 millimeters and one quart equals 0.946 liter. On many food packages, container contents are given in customary units followed by the metric equivalents. This is soft conversion.

Hard Conversion. Involving a real change in dimensions to even metric units, such as 20 millimeters or 1 liter, hard conversion necessitates resizing items in standardized metric modules.

Hard conversion is more advantageous in the long run than soft conversion because it offers tangible benefits in measurement, calculation, and production efficiency as well as in international marketing. In changing to metric modules, it is logical to reassess the item and attempt to standardize it. A reduction in array of sizes has already resulted from the change to metric units in the bottling and fastening industries (7 domestic wine bottle sizes instead of 16; 25 standard thread sizes for fasteners instead of the present 59).

Both customary and metric measuring systems will coexist for some time to come, but metric units will eventually replace the customary units as the predominant measurements in the United States as they have in most of the world. According to experiences in other countries, once adoption begins, conversion rate increases rapidly.

Standard Metric Measures. The American National Standards Institute (ANSI) through consensus of its member groups establishes the standard dimensions of modules. One ANSI committee sponsored by the American Home Economics Association has established the standards for metric measures for volumes in home food preparation as follows:

1000 mL (1 liter)	subdivided every 50 mL
500 mL	subdivided every 50 mL
250 mL	subdivided every 25 mL
125 mL	

50 mL
25 mL
15 mL
5 mL
2 mL
1 mL

The same ANSI committee, Z61.1 Committee on Dimensions, Tolerances, and Terminology for Home Cooking and Baking Utensils, established the standards for the customary measures currently used by consumers.

These measuring devices, or *measures,* have a tolerance of ± 5 percent. Some measures may be marked in both customary and metric units. Note the 1 cup mark is *not* the same as the 250 mL mark on these dual labeled measures. To avoid confusion with the smaller customary measures, metric devices should not be called *cups* or *spoons.*

Standards for measuring devices adopted in other English-speaking countries may differ from those in the United States. For dry ingredients, South Africa and United Kingdom have adopted mass measurements. Australia retained the spoon-cup terminology and use the "metric cup." They also resized the capacity of the tablespoon from 15 to 20 mL, and the cup from 237 to 250 mL. In some European countries, the term *deciliter* is used, as well as fractional rather than decimal parts. Neither deciliters nor fractions will be used in the United States and Canada.

Capacities of standard household measures (dry or liquid, small or large) in some English-speaking countries may differ from those in the United States and Canada. See lists below.

USA (1976) mL	Canada (1975) mL	United Kingdom (1970) mL	New Zealand (1971) mL	South Africa (1970) mL	Australia (1972) mL
1	1	1.25	1.25	1	1.25
2	2	2.5	2.5	2	2.5
5	5	5	5	5	5
15	15	10	10	12.5	20
25	25	15	15	25	62.5
50	50	20	62.5	50	83.3
125	125	50	125	100	125
250	250	75	250	250	250
500	500	100	500	500	1000
1000	1000	150	1000	1000	
		300			
		500			
		1000			

With usage, some units may be modified. For instance, in South Africa, the 12.5 mL measure is being phased out and replaced by a 10 mL measure.

4

METRIC USAGE IN HOME ECONOMICS

The consumer will notice the switch to metric measurements most when working with food. There will be new units to measure volume or mass (weight) of food ingredients and to measure temperature during preparation of meals every day. Food can be measured as easily with metric as with customary measures.

There will be no need for consumers to immediately discard recipes, scales, or equipment with the advent of the metric system, however. Present recipes can be used with customary cups, teaspoons, and tablespoons after the adoption of the metric system in the United States. For metric recipes, metric measuring equipment will be needed.

Food

Purchasing Units. Eventually customers will purchase food by the gram, kilogram, milliliter, or liter rather than by the ounce, pound, fluid ounce, quart, or gallon. Currently, many food labels state container contents in both U.S. customary and metric units, a soft conversion. Metric units for mass will be about 10 percent larger than customary units; those for volume about 5 percent. Therefore, with hard conversion, containers of foods sold only in metric units will be slightly larger (probably in height) than current containers to accommodate the greater amounts. The actual sizes will be determined largely by the packaging industry.

Home economists will need to adjust current food buying information for use by customers. The units should be kept simple and whole numbers should be used whenever possible.

Volume Method of Measuring. Many persons have advocated the adoption in the United States of the mass (weight) method rather than the volume method of measuring ingredients in home preparation of food. The mass method, commonly used in many large quantity food service centers and in homes in some European countries, is more accurate, easier, and faster to use for some ingredients than the volume method. However, home economists will be emphasizing volume measurements in food preparation in the home because—

- Purchase of scales is unnecessary for the degree of accuracy needed in most home preparation of food and, therefore, the cost of transition to the metric system will be minimized.

- American consumers need master only new metric units in the changeover and not a new measuring technique as well.
- Homemakers cope with fewer units when measures are the same for both liquids and solids.

New scales or new dials for current scales will be needed in quantity food service to prepare food from recipes in metric units. Scales are available with dials in both U.S. customary and metric units. A qualified service person can convert some scale dials on the premises. Other dials will need to be shipped to the factory for change. A soft conversion may be used in formulas to replace pound and ounce quantities of ingredients with kilogram and gram.

Adapting Recipes. Although home economists can readily translate recipes to metric units—a soft conversion—and use laboratory scales or graduates to measure ingredients, the average homemaker will not be able and should not have to do so. Equipment to measure food volumes for use in the home is being constructed according to metric standards. The relationships between customary and metric measures are neither simple nor direct. Therefore, distribution of recipes for use by homemakers based on a soft conversion is not recommended. Only persons well versed in metric units of measure, terminology, and usage as well as recipe development should attempt the adaption of recipes from one measurement system to another for publication.

Ratio of ingredients is much more critical in some recipes than in others—a cake compared with a stew, for instance. However, the only way to reasonably assure success is to test the adapted recipe. If the ratios among ingredients are maintained when changing quantities to metric units, the results will be substantially similar to those obtained in food preparation from the original recipe written in customary units.

The following procedure is suggested for adapting a recipe to metric measurements:

1. Make a soft conversion to metric units (milliliters or grams) for amount of each ingredient.
2. Compare the new amounts with metric measures.
   a. Can the amount be easily measured with standard metric measures, using not more than two or three measures?
   b. How large are the differences between quantities specified and those possible with the measures?
   c. Should the amount of each ingredient be increased or decreased to make it easily measurable with metric measures?
3. Write the nearest metric amount that is readily measurable for each ingredient.
4. Evaluate the metric recipe.
   a. Are the amounts of ingredients in the adapted recipe in the same proportions as in original recipe?
   b. Are the differences important for achieving the desired outcome from that recipe?
5. Refer to conversion tables in the appendix for temperature equivalents.
6. Make a soft conversion of any measurements of length—pan size, thickness of dough, or other. Check pan size to see if it will accommodate a slightly greater amount. The American National Standards Institute Z61.1 Committee on Dimensions, Tolerances, and Terminology for Home Cooking and Baking Utensils proposes changes as needed in the standard regarding dimensions of utensils in metric units.
7. Prepare food from the adapted recipe

using the standard metric measures.
8. Adjust amounts of ingredients in the recipe as necessary to achieve an acceptable product.

Developing New Recipes. New recipes should be developed using only metric measuring equipment.

In the writing of the new recipes and in converting cooking temperatures in recipes from Fahrenheit to Celsius scales, the following procedure is recommended:

1. Convert temperatures in Fahrenheit to Celsius as exactly as possible from the conversion chart in the appendix.
2. **For baking and roasting,** round the temperature in Celsius to the nearest 10. For example, if a baking temperature of 325 °F is needed, the equivalent in Celsius is 163 °C; rounding 163 to the nearest 10 would give 160 °C. **For deep-fat frying and candy-making,** round the temperature in degrees Celsius to the nearest scale division. (Scale divisions on Celsius thermometers should be no greater than 2 degrees for deep-fat frying and 1 degree for candy.) For example, if fritters are to be cooked in deep fat at 375 °F, the equivalent temperature in the Celsius scale would be 190.5; the temperature would be rounded to 190 °C—the nearest even scale division. Similarly for candy, fondant to be cooked to 240 °F would need to be cooked to 115.5 °C which would be 116 °C when rounded to the nearest scale division.

Editing Recipes. In recipes developed specifically for use with metric measures:

1. Aline ingredient names as well as their quantities and metric symbols. Alinement should be based on the first letter of a word or phrase and on the decimal marker:

Ground beef	680 g
Onion, finely chopped	75 mL
Tomatoes	175 mL
Egg, beaten	1 large

2. Include ingredient amounts in metric units only. Inclusion of two systems in one recipe distracts and tends to cause errors in measuring.
3. Specify pan sizes and temperatures in logical, rounded metric units.

Nutrition

Diet Language. Eventually Americans will measure their height in centimeters and weight in kilograms. Diet language will also be in metric units.

Americans will need to learn a new unit for energy measurements— kilojoule which replaces kilocalorie (Calorie). The new edition of *Composition of Foods—Raw, Prepared, Processed,* Agricultural Handbook 8, which is being issued in sections, gives energy data in both kilocalories and kilojoules. Since energy content of diets and energy requirements of humans usually exceed 1000 kilojoules (1 megajoule), they are generally expressed in terms of megajoules (MJ).

	Approximate Energy Values	
	kilocalories per gram	kilojoules per gram
Carbohydrate	4	17
Fat	9	38
Protein	4	17
Alcohol	7	29

Packaging Information. Currently, when food packages contain nutrition information, the units are in SI language—grams for mass and liters for volume. Nutrient contents of foods have been designated in grams, milligrams, and micrograms for years, and this practice will be continued.

Clothing

Once an item of clothing has been fitted satisfactorily, its measurements no longer concern the consumer. It is in the initial purchase or construction of clothing where the problem lies. At present in the United States there is no coordinated system of clothing sizes. Average body measurements of the population vary among countries and no size standards on which to base such a sizing system have been established for Americans.

Size Information. Men's clothing often is designated in inches by girth of neck, chest, or waist, and length of arms or legs. The American Apparel Manufacturers Association states an official preference for expressing these measurements in even metric units.

Children's clothing is usually labeled with age of a child and a descriptive term such as slim or husky. The vast ranges in sizes, growth rates, and body configurations of children make purchasing clothing difficult. A system of sizing children's clothing to reflect critical body measurements, such as used for men's clothing, should be developed and adopted in conjunction with metrication. For infants, body weight should be used as the critical factor in sizing clothing.

Clothing for women presents as much confusion as that for children. In "one size fits all" items such as panty hose, size is related to body weight. In most other women's wear, arbitrary number assignments have been made to represent an interrelationship of measures. At present, consumers cannot depend on sizes to represent standard measurements. For example: purchase of smaller sizes of more expensive women's clothes often is necessary to obtain the same fit found in less expensive garments.

With the adoption of the metric system, the producer can retain the same size designations for women's and children's clothing or convert to SI language—the consumer does not need to know what language of measure is used. However, the same problems of purchasing clothes will remain unless an integrated plan for sizing all clothing is established based on measurements of consumers in the United States.

Changes in clothing standards using metric units to describe body measurements are possible if clothing manufacturers and educators of consumers cooperate to formulate them. In a 1975 report on metrication, an American Apparel Manufacturers Association committee urged the industry to use metrication as an opportunity to re-evaluate and reduce the vast range of uncoordinated size designations found in present clothing.

Pattern Dimensions. A decade ago, pattern companies cooperatively made major changes in dimensions for pattern sizes to more nearly reflect body sizes of Americans. They recently made further revisions based on the changing body shape of American women. Patterns include all information—yardage charts, body measurements, notion requirements—in metric as well as customary units. At present, this is soft conversion due to merchandising requirements in Canada and other countries that have adopted SI metric measurements.

Home Sewing. The National Home Sewing Association is coordinating metrication in the home sewing industry including fabrics, patterns, thread, zippers, buttons, and sewing aids.

Fabric length for clothing will be measured in meters instead of yards. In other countries, fabrics are usually one meter wide (1000 mm), but widths are also currently expressed in centimeters.

Footwear. At present, size terminology for shoes refers to neither customary nor metric units.

Needlework. Knitters and crocheters may use soft conversion in replacing bust, chest, and length dimensions in favorite patterns. Yarn and wool traditionally have been sold by mass (weight) in grams or by weight/length ratios based on metric units. As metric units are introduced in the marketplace, conversion charts will be available to help consumers determine requirements.

Housing and Home Furnishings

Consumers are concerned with length in room size and arrangement, and in counter, wall, and floor coverings; with length and mass (weight) in furniture; with luminous intensity in lighting; and with length and volume in interior design and home care supplies.

Some sectors of the housing industry are studying dimensions preferred by builders and consumers in an effort to select new modules using SI units. This will lead eventually to hard conversion of building modules. However, at present most sectors favor soft conversion, changing current dimensions from feet and inches to SI units. Many builders are including dual dimensions on floor plans.

The National Lumber and Building Materials Dealers Association (NLBMDA) recommends a change from the present generic, or generic and number, sizing system for lumber to a numeric system tied to exact size. The decimal base of the metric system will simplify this sizing and minimize product identification problems, according to NLBMDA.

A meter ruler or tape and familiarity with metric measurements should provide much of the information needed for decisions about home furnishings. After the home is completed and furnishings are purchased and installed satisfactorily, their measurements are of less concern.

Floor coverings sold by the square yard are woven on looms 9, 12, or 15 feet wide (2.74, 3.66, and 4.57 meters, respectively). Existing room sizes are rarely in even multiples of feet except in modular homes and are never expressed as square yards. Measurement in metric units would be in meters.

Furniture is measured in feet or inches. The buyer's main concerns are with fit and appearance. Consumers can measure furniture and space as easily with a meter ruler or tape as with a foot ruler or yardstick.

Sizes or dimensions of household textiles (draperies, curtains, table linen, sheets, blankets, and towels) are presently stated in inches. Conversion to metric units should involve a soft conversion which may be rounded to even metric digits—centimeters.

Bedding is usually described as single, double, queen, or king size; people are measured by the foot. A twin bed, 39 by 78 inches, converts to 1 meter wide and 2 meters long and accommodates a person 6 feet 6 inches tall (2 meters). Again, a soft conversion is involved.

Household Equipment

An assortment of measurement terms is used to describe appliances and equipment used in the home. Many terms are general in nature, such as a series of numbers (1-2-3-) or words (high-medium-low) to indicate different temperature settings. Dishwashers, washers, and dryers also may be described in terms of water used or load capacity—number of place settings or weight of

clothes. Sometimes actual measurements are used to describe equipment, such as capacity of refrigerators in cubic feet, and thermostat settings on ranges and electric frypans or skillets in degrees Fahrenheit.

With a few exceptions, consumers will not be concerned about metric measurements for equipment until purchasing replacements. Exceptions include readings on thermostat dials on ovens and some surface units; capacities of saucepans, kettles, and casseroles; and dimensions of baking pans. As metric recipes become more common, these can be converted by soft conversion.

Food Preservation Equipment. With the popularity of home preservation of food, the following information will be needed:

The quantity of unfrozen food that should be placed in a food freezer at one time for freezing is 50 grams per liter of freezer space. This replaces the recommendation of 3 pounds per cubic foot.

In home canning with a pressure canner, food is to be processed at 69 kilopascals (10 pounds per square inch) steam pressure. Other steam pressure equivalents may be found in the conversion tables in the appendix.

Major Appliances. Large or major appliances presently are constructed on a 3-inch module (about 80 millimeters or 8 centimeters)—24, 30, or 36 inches wide. The change to the metric system may result in a change in these modular dimensions to 50 millimeters (about 2 inches) or 100 millimeters (about 4 inches) to conform to the proposed standard building module of 100 millimeters or 10 centimeters.

Where equipment is free-standing, consumers will not notice small changes in exterior dimensions with the adoption of the metric system. However, where appliances are built in, even slight changes in length, width, or height of a replacement item are likely to affect fit. For built-in appliances, conversions from customary to metric dimensions should be as exact as possible. If rounded to whole numbers, the rounding should be down rather than up. Where capacity is now stated in cubic feet, liters or cubic meters should be used in the metric system.

Currently, manufacturers rate appliances in watts to indicate electric input; sometimes motor-driven appliances are rated in terms of horsepower or output. The advent of the metric system will simplify comparisons of performance of gas and electric appliances. Performance with all fuels can be described in the same unit—joules. The watt, SI unit for power, equals one joule of work done in one second (J/s).

Temperature Controls. For many appliances, temperature control is essential for effective performance. However, thermostats on a number of appliances are preset at the factory and the appliance user is not likely to know what actual temperature to expect. For example: fabric settings rather than temperatures are marked on irons. The user of an automatic washer may have a choice of "hot," "warm," or "cold" water temperatures for washes and rinses; but "hot" depends upon the temperature of the water from the water heater and "cold," upon the temperature of the cold water supply to the dwelling. Similarly, the dishwasher uses "hot" water but the actual temperature depends upon the temperature of the water available from the water heater. Temperature controls on refrigerators are not marked with actual temperatures. Thus the change to metric system will make little difference in design of controls for

appliances such as automatic washers and dishwashers.

Actual temperatures are provided on control dials of cooking appliances, such as conventional range ovens and some surface units, portable ovens, electric skillets, electric saucepans, and deep-fat fryers. With adoption of the metric system, temperature markings on new control systems should be in the Celsius scale.

On some ranges temperatures in Fahrenheit are marked directly on the controls for the oven and the thermostatically controlled surface unit. Manufacturers should make available replacement controls with Celsius markings for these ranges. Changing the controls should be a fairly simple matter.

On ranges not having the temperature scale marked on the controls, conversion would be more difficult and would require more extensive changes than replacing the control. It will be necessary to include dual temperatures on new recipes for at least 10 years after adoption of the metric system in the United States because average service life expectancy of ranges is 12 to 13 years.

Range instruction manuals will contain a temperature conversion chart for a number of years to accommodate cooks with new ranges but wishing to use some old recipes. Dual temperature markings on range controls are available. Metric rather than dual controls are recommended because of better visibility. Simplified markings can improve control panel design.

Control dials for ovens of current models of ranges are marked at 25 degree intervals on a Fahrenheit scale, varying from about 150 to 550 °F with values indicated at 50 or 100 degree intervals. Control dials calibrated in the Celsius scale should be graduated in 10 degree intervals on a scale ranging from about 70 to 290 °C with values indicated at 20 or 40 degree interval marks.

Cooking Utensils. Cooking utensils may be used until they need replacing. At that time, consumers will purchase new utensils identified by shape (cake pan or loaf pan), capacity (1.4 liter mold), or critical dimensions (36 x 25 cm cookie sheet) as specified in the ANSI Z61.1 standard "Dimensions, Tolerances, and Terminology for Home Cooking and Baking Utensils." Present utensils are similarly identified but in customary units.

Replacement Parts. Many manufacturers and retailers will continue to stock replacement parts for old appliances after the change to metric measurements.

5

GENERAL STYLE AND USAGE

This section of the *Handbook of Metric Usage* is presented in style manual form to help writers and editors find answers quickly to metric style and usage questions. The rules are based on current standards for metric practice in the United States.

Abbreviations

SI is the abbreviation for Le Système International d'Unités (The International System of Units).

Units should be stated completely. A prefix is not used alone, either written or in speech:

kilogram **not** kilo
minus 10 °C **not** 10 below

Symbols

Avoid mixing unit names, symbols, and words.

8.5 m **not** 8 m 500 mm
meter per second **not** meter/second
m/s **not** m/second

Symbols rather than abbreviations are used in the metric system.

Capitalization of Symbols. Symbols are written in lower case except for unit names derived from a person's name:

A (ampere) J (joule) Pa (pascal)
C (Celsius) K (kelvin) V (volt)
Hz (hertz) N (newton) W (watt)

NOTE: Spell *liter* in full wherever possible, except when using with a prefix. When the symbol is necessary, use the capital L:

20 liters 20 mL

Symbols for prefixes are lower case letters except for those denoting a million or more:

M (mega) G (giga) T (tera)
P (peta) E (exa)

Punctuation of Symbols. A period is used after a symbol only at the end of a sentence. SI is written without periods:

km **not** km.
SI **not** S.I.

Plurals. Symbols of units are always singular:

10 km **not** 10 kms

Spacing. A space is left between number and symbol. The exception is degree Celsius:

20 mg **not** 20mg
20 °C **or** 20°C

Compound Units. A centered dot is used for the symbol of a compound unit that is formed by multiplication of two or more units:

N·m

Square and Cubic Units. In designating units such as square meters or cubic meters, the symbol of the unit includes the superscript 2 or 3. The prefix is raised to the same order, also:

$20\ m^2$ = 20 square meters
$3\ m^3$ = 3 cubic meters
$1\ mm^3 = 10^{-9} m^3$ **not** $10^{-3} m^3$

When the name of a unit contains *per*, the symbol requires a slash (oblique stroke) or a negative exponent. The abbreviation kph for kilometers per hour should be avoided:

50 m/s or $50\ m \cdot s^{-1}$
(50 meters per second)
75 km/h (75 kilometers per hour)

Capitals

Names of SI units, except Celsius, start with a lower case letter except when used at the beginning of a sentence (see 1.3. for capitalization of symbols):

kilogram **not** Kilogram
watt **not** Watt
Celsius **not** celsius

Compound Units

When writing the name of a compound unit, a space or a hyphen is used (the space is preferred):

newton meter
or
newton-meter

Compound prefixes are not used:

nanometer (nm)
not
millimicrometer (m μ m)

Decimals

A decimal value is used to express partial units.

The decimal is indicated by a period on the line. In some countries, a comma is used to indicate the decimal marker, but in the United States and Canada, a period is preferred. For numbers less than 1, a zero is inserted before the period because of the possibility that the decimal point will be overlooked:

0.5 liter **not** 1/2 liter or .5 liter

Derived Units

To form derived units, use only metric units themselves and not multiples or submultiples of the units:

N/m^2 **not** N/cm^2

Prefixes may be applied to the numerator of the derived unit but not to the denominator:

MN/m^2
(meganewton per square meter)

EXCEPTION: Kilogram may be used in the denominator because kilogram is the SI base unit for mass.

Nomenclature

Use established SI nomenclature throughout.

For clarity, do not mix metric and customary terminology:

250 mL **not** 1 metric cup
500 g **not** 1 metric pound
kilograms per cubic meter (kg/m³)
not
kilograms per gallon (kg/gal)

During the transition period, include customary units in parentheses in text or small tables. The unit listed first in tables or text should be regarded as standard. Units given in parentheses are approximate.

Restate an equation using SI quantities.

Use dual scales in charts or graphs.

NOTE: Retain only the number of decimals needed for desired accuracy but which do not exaggerate the accuracy.

Plurals

Names of units are plural where appropriate:

10 kilometers **not** 10 kilometer

Fractions (common and decimal) are always singular. Symbols of units are always singular:

0.15 milligram **not** 0.15 milligrams
10 km **not** 10 kms

Plural form for the unit of temperature is degrees Celsius.

Spacing

A space is left between groups of three numbers counting from the decimal point in either direction. A comma is not used to separate numbers into groups because in some countries a comma denotes the decimal:

21 345 **not** 21,345

A space is not recommended in four-digit numbers unless the four-digit number is in a column containing numbers with five or more digits.

When prefixes are used, no space is left between the prefix and the unit name or between symbols for the prefix and unit name (see **Symbols** section for spacing of numbers and symbols):

kg **not** k g
kilogram **not** kilo gram

Conversion

If it is necessary to convert measurements from one system of measurement to another, multiply the quantity by the conversion factor (see Appendix), then round to the appropriate number of significant digits and adjust the prefix as needed.

Rounding

There are several ways of rounding. Following are examples of procedures appropriate for applications in home economics.

Round result to a precision equivalent to the original:

To convert 2 ounces to grams, multi-

ply 2 ounces by the conversion factor 28.35 and round the resultant to a precision equivalent to the original value. Before rounding, the result is 56.70. Scales are usually divided in 1/4-ounce units (approximately 7-gram units). Thus, round result to 57 grams (units position) for nearest equivalence without sacrificing precision. Rounding to 60 grams (tens position) is less precise (about 5 percent).

Round result to the same number of significant digits as in the original:

To convert 10 gallons to liters, multiply 10 gallons by the conversion factor 3.785. The result is 37.85 liters. Round to 40 liters (tens position) which is about 5 percent larger than 10 gallons.

Convert the result to the scale marking of the metric measure:

To convert 75 °F to °C, divide 75 °F minus 32 °F by 1.8, which equals 23.889 °C. Round this result to 24 °C because that is the nearest integral scale value on the Celsius thermometer.

For many practical purposes, units may be rounded as follows:

Numbers	Round to
1 to 10	nearest digit (whole number)
10 to 100	nearest 5 or 10
100 to 1000	nearest 10

Metric Arithmetic

Metric is a decimal system—based on tens. The prefixes state the position of the decimal, just as in our money system. A cent may be thought of as 1 centidollar or 10 millidollars. Similarly, 0.001 kilometer = 1 meter = 1000 millimeters.

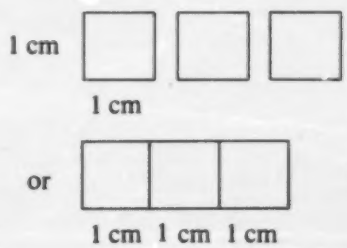
In adding units, convert all amounts to the same unit by moving the decimal point the appropriate number of places, and then add:

2 m	=	200 cm	**or**	2.00 m
75 cm	=	75 cm		0.75 m
125 cm	=	125 cm		1.25 m
135 mm	=	13.5 cm		0.135 m
		413.5 cm		4.135 m

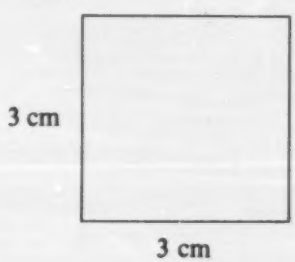
Subtracting metric numbers is done in the same manner as adding numbers. In multiplying and dividing numbers, move decimal point so units (if any) are the same in all factors:

$$6\text{ cm} \times 12\text{ m} = 0.06\text{ m} \times 12\text{ m} = 0.72\text{ m}$$

In designating units of area, the correct terms are three square centimeters and 3 cm^2:



A three-centimeter square or 3-cm square has sides 3 cm in length and an area of 9 cm^2:



Units of volume are in the same terms. The volume of a ten-centimeter cube is 1000 cm^3, 1000 mL, or 1 liter, whereas the volume of ten cubic centimeters is 10 cm^3.

Pronunciation

All prefixes are accented on the first syllable.

kilogram is KILL-o-gram
not KEEL-O- gram

kilometer is KILL-O-meter
not kill- AHM-itur

The unit for energy, *joule,* is pronounced JOOL.

The temperature scale, *Celsius,* is pronounced SELL-see-us.

The symbol μ (a Greek letter) is pronounced MEW not MOO. However, when combined with a unit symbol such as with M, the combination is pronounced MICRO-me-ter **not** MEW-meter.

6

LEARNING ACTIVITIES

Measurement learning activities can apply directly to home economics. This section includes some examples of activities in the areas of food, nutrition, clothing, home furnishings, and household equipment. Some of the activities may be offered twice—once with customary and once with metric measurements—to illustrate the simplicity of the metric system. None of the activities involves conversion of units. In presenting metric material to learners, **THINK METRIC** is the keynote.

Teachers or leaders can develop learning activities which involve interrelationships of prefixes, units of measurement for different quantities, and symbols, using the information presented in this handbook. These activities are not presented here because many publications contain such examples. The following activities were selected for their direct application to home economics.

Food

- Estimate the number of liters of water in a pail, bowl, or pot. Measure to see how close you are to the correct answer. Use a scale to find the mass of water.
- Using sand or water, show that a 1000 cm^3 cube and 1 liter cylinder have the same capacity. What is the relationship of mass and volume?
- At the grocery store, how many items contain metric symbols? How many were correct? Incorrect?
- Measure 100 milliliters of flour or 100 milliliters of water and use a scale to determine which is heavier.
- Record temperatures in the refrigerator, the freezer, the room, and the human body. Using this information, estimate the temperature out-of-doors.
- Measure mass (weight) of 125 mL of each of the following ingredients:

sugar	dry milk	French dressing
rice	honey	cooking oil
flour	water	dry flaked cereal
salt	cornmeal	

As an alternative, measure the volume of 100 grams of each of the above ingredients. Discuss reasons for the differences.

- Calculate the ingredient amounts needed to serve punch to the class or group from the following two-serving recipe:

Cranberry juice, bottled	125 mL	
Apple juice	75 mL	1/3 cup

Lime juice	5 mL	1 teaspoon
Frozen limeade concentrate	30 mL	1 fluid ounce

- If a kilogram of an item costs $5.95, how much does 50 grams cost?
- Compare price and weight (mass) of three or more boxes of the same product sold in different sizes to see which is the best buy.

Nutrition

- Observe where the metric system is used in nutrition labeling.
- Research how many kilojoules per day your diet should contain.
- What is your weight (mass) in kilograms? Look up your desirable weight (mass) on a height-weight (mass) chart and determine the difference.

Clothing

- Measure your bust (chest), waist, hips, and height in centimeters and determine your pattern size. Measure your back waist length and skirt or pants length. Adjust pattern accordingly.
- Gulliver travelled to Lilliput and was treated to a new set of clothes. His hosts measured his right thumb and made a suit for him based on that measurement. They computed that twice round the thumb is once round the wrist, twice around the wrist is once around the neck, and twice around the neck is once around the waist. Do you think Gulliver's new shirt fit? Try this out for yourself using a centimeter tape measure.
- Shop for wearing apparel or sewing items which carry labels or descriptions in metric terms. Report findings to group. Research how clothing is sized in other countries which use metric units. Discuss your findings.
- Do any sewing tools or sewing machine parts need to be altered for sewing in metric? If yes, what tools and/or parts need to be changed?
- Estimate the size of zippers, buttons, seam tapes, and other sewing notions in metric units. Now measure the sizes. How close were you?

Home Furnishings

- How much paint in metric units is required for the walls and ceiling of the room you are in? One liter will cover 10 square meters. Is it easier to calculate the size of the room in metric or customary units? Why?
- Assume you are buying a bookcase to fit under a window. What would be its maximum height and width in centimeters? Make a metric scale drawing of the bookcase.

Household Equipment

- What are the inside dimensions of your freezer and refrigerator in meters? Calculate their capacities in cubic meters in liters.
- Measure the dimensions of baking pans, such as loaf, cake, and pie pans. Mark the pans with the metric units. Determine the capacities in liters of saucepans, casseroles, kettles, canisters, ice cube trays. Mark these with metric units.
- Assume you will replace the built-in range, oven, surface units, or dishwasher. What are the minimum and maximum dimensions of the appliance that will fit into the allotted space? Will the door or lid swing freely?
- Discuss the units of measurement which will not change with the advent of the metric system.
- Determine the mass (weight) of the

following pieces of equipment in kilograms: portable mixer, electric knife, toaster oven, microwave oven, blender, and portable sewing machine. Arrange them from lightest to heaviest. Which appliances have a mass that is similar to a textbook, a kitchen chair, and a typewriter?

APPENDIX

Conversion Factors

Continual converting of measurements by consumers can complicate the change-over to the metric system. Familiarity with actual sizes and amounts in metric units is easier and more effective than conversion in adoption of the metric measurement system. However, home economists who prepare teaching materials and information for consumers may need to use conversion factors to facilitate their job.

Quantity	Unit	Approximate equivalent	
Length	inch	25.4	millimeters (exact)
	foot	304.8	millimeters
	yard	0.914	meter
	mile	1.609	kilometers
Mass (weight)	ounce	28.35	grams
	pound	453.59	grams
Volume	cubic meter	1000	liters
	liter	0.001	cubic meter
	fluid ounce	29.573	milliliters
	teaspoon	4.93	milliliters
	tablespoon	14.79	milliliters
	cup	236.58	milliliters
		0.237	liter
	pint	0.473	liter
	quart	0.946	liter
	gallon	3.785	liters
		0.0038	cubic meter
	cubic foot	28.317	liters
		0.0283	cubic meter

Quantity	Unit	Approximate Equivalent
Temperature	degree Fahrenheit	$\frac{t_{\cdot F} - 32}{1.8} = t_{\cdot C}$
Area	square inch	645.2 square millimeters
	square foot	0.0929 square meter
	square yard	0.836 square meter
	square mile	2.590 square kilometers
	acre	4 046.9 square meters
	hectare	10 000 square meters
Energy, work, quantity of heat	British thermal unit	1 055 joules
	kilocalorie	4.185 kilojoules
	horsepower-hour	2.6845 megajoules
	watt-hour	0.860 kilocalorie
		3.600 kilojoules
Power	British thermal unit per second	1.054 kilowatts
	horsepower	0.746 kilowatt
Pressure	pounds-force per square inch	6.895 kilopascals
	atmosphere (normal)	101.325 kilopascals
		760 millimeters of mercury
		14.696 pounds-force per square inch

Conversion Tables

VOLUME

Unit	Approximate replacement in U.S. customary units
1 milliliter (1 mL)	0.20 teaspoon
2 milliliters (2 mL)	0.40 teaspoon
5 milliliters (5 mL)	1.01 teaspoon
15 milliliters (15 mL)	3.04 teaspoons
	1.01 tablespoon
25 milliliters (25 mL)	1.69 tablespoons
50 milliliters (50 mL)	3.38 tablespoons
60 milliliters (60 mL)	0.25 cup
75 milliliters (75 mL)	0.32 cup
100 milliliters (100 mL)	0.42 cup
125 milliliters (125 mL)	0.53 cup
250 milliliters (250 mL)	1.06 cups
500 milliliters (500 mL)	2.11 cups
1000 milliliters (1000 mL)	4.23 cups
	1.06 quarts

TEMPERATURE

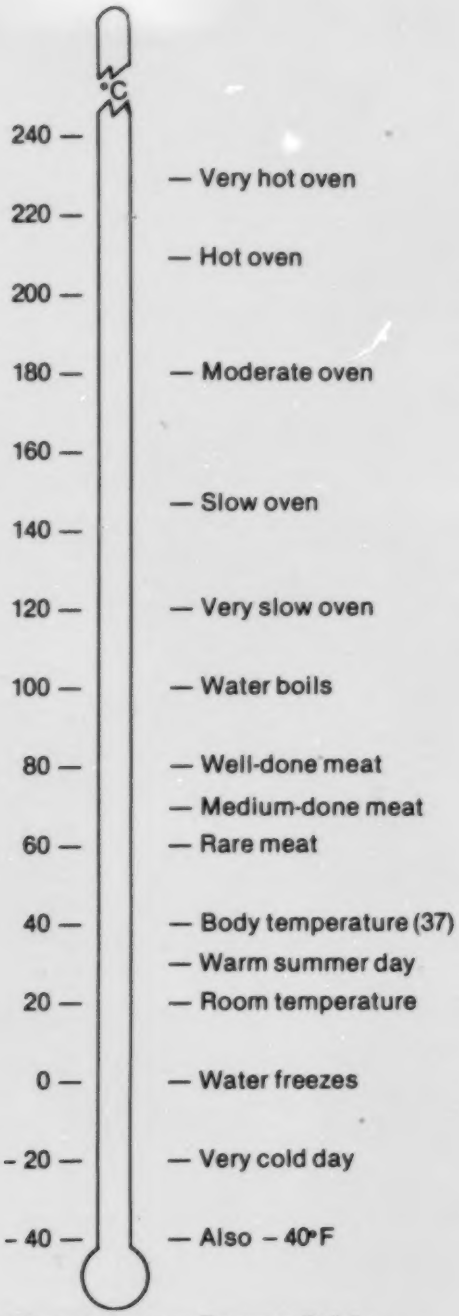
The numbers in the body of the table give in degrees Fahrenheit the temperature indicated in degrees Celsius at the top and side.

To convert 352 °F to Celsius scale, find 352 in the series of Fahrenheit readings, then in the column headed degrees Celsius, find the number which is on the same horizontal line, i.e., 17. Next, fill in the last number from the heading of the column in which 352 was found, i.e., 8, resulting in 178 °C which is equivalent to 352 °F.

°C	0	1	2	3	4	5	6	7	8	9
	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F
– 2	– 4	– 6	– 8	– 9	– 11	– 13	– 15	– 17	– 18	– 20
– 1	14	12	10	9	7	5	3	1	0	–2
– 0	32	30	28	27	25	23	21	19	18	16
0	32	34	36	37	39	41	43	45	46	48
1	50	52	54	55	57	59	61	63	64	66
2	68	70	72	73	75	77	79	81	82	84
3	86	88	90	91	93	95	97	99	100	102
4	104	106	108	109	111	113	115	117	118	120
5	122	124	126	127	129	131	133	135	136	138
6	140	142	144	145	147	149	151	153	154	156
7	158	160	162	163	165	167	169	171	172	174
8	176	178	180	181	183	185	187	189	190	192
9	194	196	198	199	201	203	205	207	208	210
10	212	214	216	217	219	221	223	225	226	228
11	230	232	234	235	237	239	241	243	244	246
12	248	250	252	253	255	257	259	261	262	264
13	266	268	270	271	273	275	277	279	280	282
14	284	286	288	289	291	293	295	297	298	300
15	302	304	306	307	309	311	313	315	316	318
16	320	322	324	325	327	329	331	333	334	336
17	338	340	342	343	345	347	349	351	352	354
18	356	358	360	361	363	365	367	369	370	372
19	374	376	378	379	381	383	385	387	388	390
20	392	394	396	397	399	401	403	405	406	408
21	410	412	414	415	417	419	421	423	424	426
22	428	430	432	433	435	437	439	441	442	444
23	446	448	450	451	453	455	457	459	460	462
24	464	466	468	469	471	473	475	477	478	480
25	482	484	486	487	489	491	493	495	496	498
26	500	502	504	505	507	509	511	513	514	516
27	518	520	522	523	525	527	529	531	532	534
28	536	538	540	541	543	545	547	549	550	552
29	554	556	558	559	561	563	565	567	568	570
30	572	574	576	577	579	581	583	585	586	588

GAUGE PRESSURE AT SEA LEVEL AND BOILING POINT OF WATER

Pressure		Temperature	
Pounds per Square Inch psi	Kilopascal kPa	Boiling Water °F	°C
1	7	216	102
5	34	228	109
10	69	239	115
15	103	250	121
20	138	259	126
25	172	268	130
30	207	275	135



Temperatures—Degrees Celsius

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ASME Orientation and Guide for Use of SI (Metric) Units, ASME Guide SI-1. Fifth edition. New York: American Society of Mechanical Engineers, 1974. 30 pp.

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Handbook of Food Preparation. Seventh edition. Washington, D.C.: American Home Economics Association, 1975. 120 pp.

International System of Units (SI). U.S. Department of Commerce. National Bureau of Standards Special Publication 330. Washington, D.C.: Government Printing Office, 1974.

Metric Editorial Guide. Second edition. Washington, D.C.: American National Metric Council, 1975.

Metric Guide for Educational Materials. Washington, D.C.: American National Metric Council, 1977.

Seast, R.C., and Selby, S.M. *Handbook of Chemistry and Physics.* Cleveland: Chemical Rubber Company Press, Inc.

Metrication in Home Economics
—A Selected Bibliography
by Judy Oppert

The following organizations and individuals have metric materials which I believe may be useful as you work with consumers. Many of the organizations and people listed below will supply additional information describing their products at no charge. When there is a charge, it is suggested that the products be ordered on approval.

CONVERSION DEVICES

The average consumer will rely on professionals to publish charts and supply information when measurement units in one system need to be converted to units in the other system. As a professional educator you do not need to spend a great amount of time referring to conversion charts and performing arithmetic calculations. You may already have a calculator that will perform the calculations. Also, many companies have assembled conversion devices that can quickly supply appropriate equivalents in either measurement system. Contact the nearest U.S. Army Recruiting Office for a free converter. This converter does not contain scales small enough to convert ounces and grams or millimeters and cups. A converter which contains these smaller units can be ordered. The Deluxe Cook 'N Sew Converter (Product Code CS-1) is available for $2.50 from:

The Educational Aids Department
Union Carbide Research Center
P.O. Box 363
Tuxedo, N.Y. 10987

A class pack containing 25 student converters plus one deluxe model is available from the same company for $15.00 (Product Code CS-2).

EDUCATION

Education, Stock No. 0303-0858, $2.30 from: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Lampman, D. "Metrication of the American Family." *The Arithmetic Teacher,* Dec. 1974, 21 (8), 707-709.

Metric Education from: Agency for Instructional Television, Box A, Bloomington, Ind. 47401.

Metric Education: An Annotated Bibliography for Vocational, Technical and Adult Education. $10. Bibliography Series No. 26. The Center for Vocational Education, The Ohio State University, 1960 Kenny Road, Columbus, Ohio 43210.

Shumway, R. J., and Sachs, L. "Don't Just Think Metric—Live Metric." *The Arithmetic Teacher,* Feb. 1975, 22 (2), 103-110.

Successful Experiences in Teaching Metric, SD Catalog No. C13.10:441. $2.88. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Tardif, R., Hoffman, J., and Lorenzen, F. *Interstate Consortium on Metric Education.* Bureau of Publications, California State Department of Education, 721 Capitol Mall, Sacramento, Calif. 95814.

Taylor, R., and Gawronski, J.D "Think Metric Week in Minneapolis." *The Arithmetic Teacher,* March 1975, 22 (3).

GAMES

Buckeye, D.A. *I'm OK, You're OK,*

Let's Go Metric. $3.25. Order on approval from Midwest Publications Co., Inc., P.O. Box 129, 1700 W. Maple Road, Troy, Mich. 48084.

Clack, A., and Leitch, C.H. *Amusements in Developing Metric Skills.* $3.75. Order on approval from Midwest Publications Co., Inc., P.O. Box 129, 1700 W. Maple Road, Troy, Mich. 48084.

Henderson, G.L., and Glunn, L.D. *Let's Play Games in Metrics.* $6.25. Order on approval from National Textbook Company, 8259 Niles Center Road, Skokie, Ill. 60076.

Ploutz, P.F. *Decimeter* (game). $11. Order on approval from The Lawhead Press, Inc., 900 E. State Street, Athens, Ohio 45701.

Trueblood, C.R., and Szabo, M. "Procedures for Designing Your Own Metric Games for Pupil Involvement." *The Arithmetic Teacher,* May 1974, 21(5), 404-408.

GENERAL

All You Will Need To Know About Metric (For Your Everyday Life). Chart or flyer which may be reproduced, from Metric Information Office, National Bureau of Standards, Washington, D.C. 20234.

Barbrow, L.E. *What About Metric?* Stock No. 0303-01191. $1.10. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

An Educator's Guide to Teach Metrication from Consumer Information Services—D/703, Chicago, Ill. 60684.

Everything You Have Always Wanted To Know About Weights and Measures. R.T. Williams, Director, TDA Consumer Service Division, P.O. Box 12847, Capitol Station, Austin, Tex. 78711.

Glaser, A. *Neater By the Meter.* $3.50 paperbound or $6.50 hardbound. Order from Anton Glaser, 1237 Whitney Road, Southampton, Pa. 18966.

Going Metric. $.25. Channing L. Bete Co., Inc., 45 Federal Street, Greenfield, Mass. 01301.

Holt, S.F. *The United States and the Metric System (Exponent)* from Office of Public Information, Federal Reserve Bank of Minneapolis, Minneapolis, Minn. 55480.

The International System of Units (SI). NBS Special Publication 330. $.65. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Izzi, J. *Metrication, American Style.* $.50. Order from: Phi Delta Kappa, Eighth and Union, Box 789, Bloomington, Ind. 47401.

"Moving Toward Metric," *Insights Into Consumerism,* No. 84573. Available free from the manager of your nearest J.C. Penney Store or for $1.25 from Educational Relations, J.C. Penney Company, Inc., 1301 Avenue of the Americas, New York, N.Y. 10019.

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Brief History of Measurement Systems With a Chart of the Modernized Metric System. Stock No. 0303-01073. $.30. Superintendent of

Documents, U.S. Government Printing Office, Washington, D.C. 20402.

The Kilos Are Coming. 44 colored slides, script, resource list, guide, activities. $20. Mrs. Virginia Jodoin, 211 Terrill Hall, University of Vermont, Burlington, Vt. 05401.

A Metric America, A Decision Whose Time Has Come. Stock No. 0303-00884. $2.70. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

HOME ECONOMICS

Anderson, R. *Metrics: A Resource Guide for Home Economics* (to be available through ERIC), microfiche. VEIN, Stayer Research and Learning Center, Millersville State College, Millersville, Pa. 17551.

American Metric Beef Cookbook. $2.50. Beef Industry Council, 444 Michigan Avenue, Dept. BOOKS, Chicago, Ill. 60611.

Batcher, O.M., and Young, L.A. "Metrication and the Home Economist." *Journal of Home Economics,* Feb. 1974, 66(2), 28-31.

The Consumer. Stock No. 0303-0864. $1.75. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Cooking the Metric Way: An Easy Guide To Good Nutrition (recipe book). $3. BCHEA Metric Cookbook, 2268 Kensington Avenue, Burnaby, British Columbia V5B 4E2.

Cooking With Metrics (60 recipes). $7. B.H.U., 23358 Hartland Street, Canoga Park, Calif. 91307.

Darling, M. *Metrics in the Kitchen.* Extension Folder 294-1974. University of Minnesota, Agricultural Extension Service, St. Paul, Minn. 55101.

Educator's Guide To Metric For Clothing Construction. $.25. Coats & Clark Inc., Consumer and Educational Affairs Department, 72 Cummings Point Road, Stamford, Conn. 06902.

Gaucher, C., and Perry, S. "What Impact Will Metrication Have on Home Economics?" *Forecast for Home Economics,* March 1974, pp. F-14-16.

Handbook of Food Preparation. $4. American Home Economics Association, 2010 Massachusetts Ave. NW, Washington, D.C. 20036.

How To Metricook (recipes). Home Service Bureau, Maple Leaf Mills Limited, 43 Junction Road, Toronto, Ontario M6N 1B5.

Measuring Metric in Fashion Sewing. 35 mm film strip, audio cassette, teaching guide. $15. The Education Department, The McCall Pattern Company, 230 Park Avenue, New York, N.Y. 10017.

Metrics in the Kitchen. 35 mm film strip, teacher's guide, wall chart, 30 student leaflets, oven temperature sticker. $35. General Mills Canada, Ltd., P.O. Box 505, 1330 Martin Grove Road, Rexdale, Ontario M9W 4X4.

Miller, B.S., and Trimbo, H.B. "Use of Metric Measurements in Food Preparation." *Journal of Home Economics,* Feb. 1972, 64(2), 20-25.

Oppert, Judy. "Metric Recipes for Classroom Use." *Illinois Teacher of Home Economics,* Jan./Feb. 1977, 20(3), 131-133.

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Schlessinger, P.E., and Kennedy, B.M. "Metric Measurements in Food Preparation." *Journal of Home Eco-*

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SI . . . A Metric Workbook for Teachers of Consumer and Homemaking Education. $1.50. Contains transparency masters. Orange County Department of Education, 1250 South Grand Avenue, P.O. Box 11846, Santa Ana, Calif. 92711.

METRIC MEASURING TOOLS

Catalogs are available from the following companies:

Dick Blick, P.O. Box 1267, Galesburg, Ill. 61601.

Housewares Division, Foley Manufacturing Company, 3300 N.E. Fifth Street, Minneapolis, Minn. 55418.

Ideal School Supply Company, 11000 South Lavergne Avenue, Oak Lawn, Ill. 60453.

Math Shop Inc., 5 Bridge Street, Watertown, Mass. 02172.

Sargent-Welch Scientific Company, 7300 North Linder Avenue, Skokie, Ill. 60076.

Selective Educational Equipment (see), Inc., 3 Bridge Street, Newton, Mass. 02195.

Spectrum Educational Supplies Limited, 8 Denison Street, Markham, Ontario L3R 2P2.

Metric measuring supplies also are available from:

Five stainless steel spoons (1, 2, 5, 15, and 25 mL), #02-003, $1.75 (school price), and 3 stainless steel cups (50, 125, and 250 mL), #02-004, $2.50. From Metric Shop, Box 392, 720 Cayuga Street, Lewiston, N.Y. 14092.

Five plastic spoons, #599, $1.95. Three plastic cups, #598, $1.95. Sizes are the same as above. From Educational Teaching Aids, 159 W. Kinzie Street, Chicago, Ill. 60610.

In addition to many of the above companies, scales are available from:

Ramor Sales (Pelouze dietetic scales, $25.95), 1740 E. Summit Court, Deerfield, Ill. 60015.

Swani Publishing Co. ("Think Metric" bathroom scales, $9.95), P.O. Box 248, Roscoe, Ill. 61073.

ORGANIZATIONS

Contact your nearest Cooperative Extension Service office. Many states have developed metric publications and/or slide sets.

Metric Commission, 320 Queen Street, Ottawa K1A 0H5.

Metric Information Office, National Bureau of Standards, Washington, D.C. 20234.

PERIODICALS

A.I.R. Metri-gram, published five times during the school year. $5.50 if payment accompanies order. $6.50 if billing is requested. Its goal is to keep instructors and administrators abreast of what is happening in metric education in the U.S. and in the other countries going metric. American Institutes for Research, Metric Studies Center, P.O. Box 1113, Palo Alto, Calif. 94302.

American Metric Journal, bimonthly publication of metric training educational progress. $35 per year, from AMJ Publishing Company, Drawer L, Tarzana, Calif. 91356.

Metric Monitor, published by Metric Commission, Box 4000, Ottawa, Ontario K1S 5G8.

Metric Association Newsletter, published four times per year, cost included in $3 membership fee per year, from U.S. Metric Association, Inc., Sugarloaf Star Route, Boulder, Colo. 80302.

Metric News, bimonthly publication. $5 per year, from Swani Publishing Company, P.O. Box 248, Roscoe, Ill. 61073.

Metric Reporter, published biweekly (26 issues per year). $25 per year from American National Metric Council, 1625 Massachusetts Avenue, NW, Washington, D.C. 20036.

Ogontz Metric News, edited by Dr. Anton Glaser, Ogontz Campus, PSU, Abington, Pa. 19001.

POSTERS

"Think Metric Posters." Eight posters, No. 214-510. $3.50 from Scholar's Choice Limited, Learning Materials, 50 Ballantyne Avenue, Stratford, Ontario N5A 6T9.

TEACHER EDUCATION

Chalupsky, A.B.; Crawford, J.J.; and Carr, E.M. *Going Metric: An Analysis of Experiences of Five Nations and Their Implications for U.S. Educational Planning.* National Institute of Education Project No. 3-2173, Final Report. Palo Alto, Calif.: 1974. $5.40 if payment accompanies order. $6.40 if billing is requested. From American Institutes for Research, Metric Studies Center, P.O. Box 1113, Palo Alto, Calif. 94302.

Oppert, J. "Opportunity to Learn Metrics!" (Correspondence course for home economics teachers) *Illinois Teacher of Home Economics.* 18(2-5). $7. (Address below).

Parsons, E. "Introducing The Metric System into the Home Economics Classroom," *Illinois Teacher of Home Economics,* 18(5); 19(1-2). $5.25. Illinois Teacher of Home Economics, 351 Education Building, University of Illinois, Urbana, Ill. 61801.

VISUAL MASTERS

Metric Measurement Kit. $2.50 from Link Educational Laboratories, Box 25, Hope Hull, Ala. 36043.

Guidelines for Selecting Metric Instructional Materials

by Judy Oppert

METRIC MATERIAL	YES	UNSURE	NO	COMMENT:
Objectives (stated or unstated)				
Are they attainable?				
Are they desirable?				
Are they appropriate for students?				
Are the educational materials consistent with objectives?				
Are objectives consistent with educational approach and philosophy of the school and department?				
Appearance and Use				
Is it attractive?				
Are pictures, symbols and lettering appropriate for students (age, reading level, timeliness, sex and ethnic groups)?				
Is it easy to identify and store?				
Is it easy to use?				
Information				
Does it stress significant concepts of the metric system?				
Will the information be useful and relevant to students?				
Is it accurate?				
Does it make the metric system seem as simple as it is?				

Information (continued)	YES	UNSURE	NO	COMMENT:
Is information given adequate?				
Is it understandable and clear?				
Is it well organized?				
Learning Activities				
Are there appropriate "hands on" experiences?				
Are they challenging to, but not beyond the ability of, students?				
Are there clear directions, if necessary?				
Is the sequence of activities appropriate and interesting?				
Availability				
Can the materials be ordered on approval?				
If the materials are expensive, can they be shared?				
Is the cost consistent with the value?				
Are the materials well constructed and durable?				
Can parts that will be used up, broken or lost be reproduced or replaced?				
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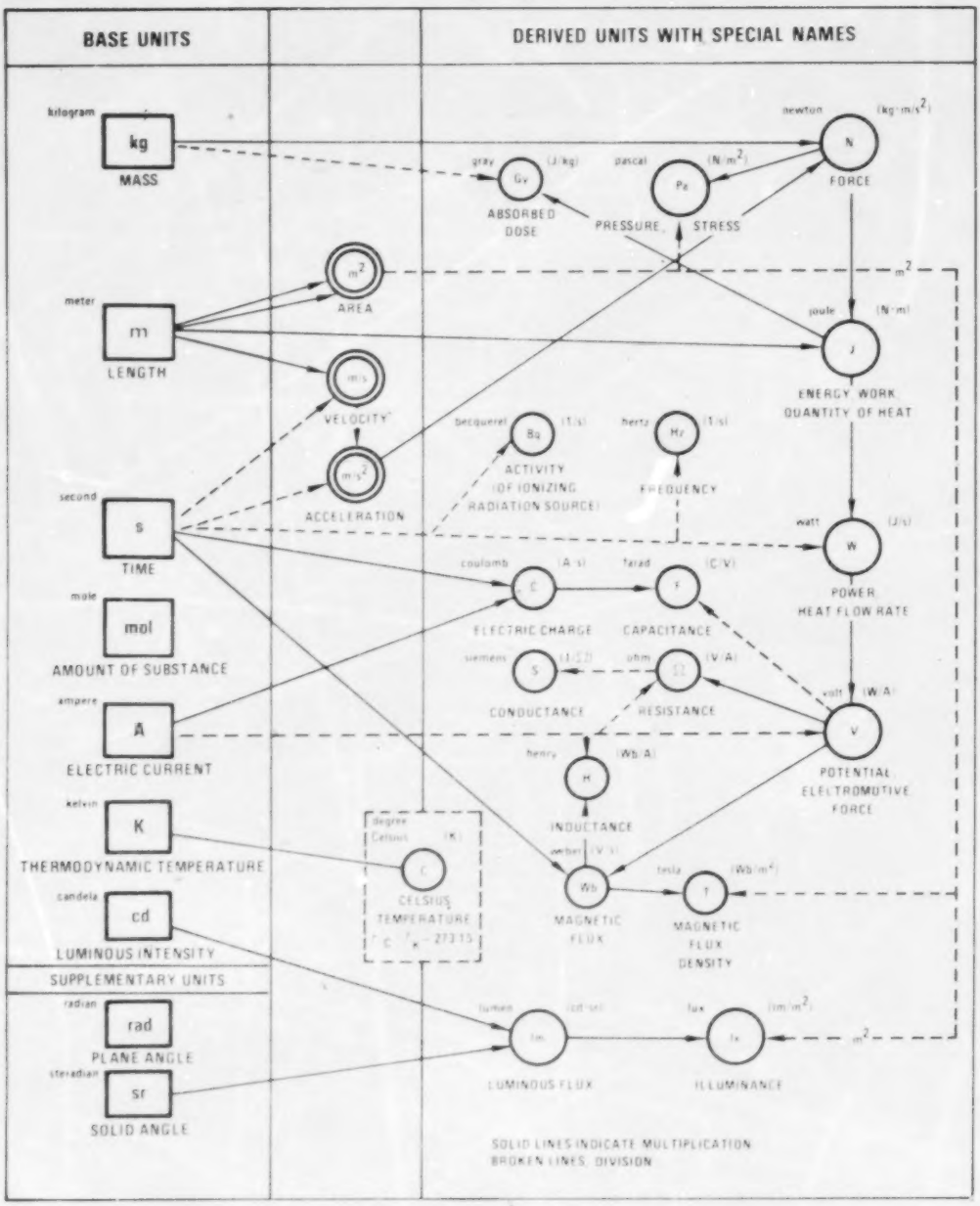
RELATIONSHIPS OF SI UNITS WITH NAMES



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